GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ____

Project No. E-27-604 (R6155-0A0) GTRC/~~GIT~~ DATE 7 / 9 / 86

Project Director: Dr. Walter C. Carter School/~~Lab~~ XXX TE

Sponsor: Astroturf Industries, Inc.

Type Agreement: Research Project Agreement dated 6/17/86

Award Period: From 6/17/86 To 10/16/86 (Performance) 10/16/86 (Reports)

Sponsor Amount:	This Change	Total to Date
Estimated:	$ 12,479	$ 12,479
Funded:	$ 12,479	$ 12,479 + $1,248 P&D Rights

Cost Sharing Amount: $ None Cost Sharing No: N/A

Title: A Sewing Thread Having Improved Stability to Outdoor Exposure

ADMINISTRATIVE DATA OCA Contact Brian J. Lindberg X4820

1) Sponsor Technical Contact:

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Directorate, Market Development
Astroturf Industries, Inc.
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2) Sponsor Admin/Contractual Matters:

Same as 1)

Defense Priority Rating: N/A Military Security Classification: N/A

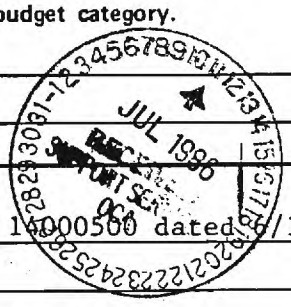
(or) Company/Industrial Proprietary: See Below

RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed or anticipated.



COMMENTS:

An advanced payment of $3,120 has been received by check no 14000500 dated 6/18/86.

X A Non-Disclosure Agreement has been negotiated.

Sponsor to pay $1,248 for patent and publication review rights.

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GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 8/18/87

Project No. E-27-604 School/~~Lab~~ TE

Includes Subproject No.(s) N/A

Project Director(s) Dr. Walter C. Carter GTRC / ~~GIT~~

Sponsor Astroturf Industries, Inc.

Title A Sewing Thread Having Improved Stability to Outdoor Exposure

Effective Completion Date: 10/16/86 (Performance) 10/16/86 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None *No deliverables
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [X] Final Report of Inventions _ Sent Ouestionnaire to P.I.
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

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Duane H.
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PROGRESS REPORT

ON

RESEARCH PROJECT NO. E-27-6Ø4

FOR

ASTRO-TURF INDUSTRIES, INC.

A SEWING THREAD HAVING IMPROVED STABILITY TO OUT-DOOR EXPOSURE

WALTER C. CARTER

JULY 14, 1986

Progress Report

A Sewing Thread Having Improved Stability
to Outdoor Exposure

I. Introduction

Phase I of this work has the following objectives:

1. To make a literature search concerning how the out-door environment affects the stability of fibers, principally their photostability.

2. To consult with those people who have interests in sewing threads including those who make thread and those who are involved in sewing to discover the best routes to a new sewing thread for outdoor applications.

3. To establish candidate sewing threads for use in sewing Astro Turf fabrics.

II. Accomplishments

1. Literature Search

A computer literature search has been made with the assistance of the Georgia Tech Library. Many useful references were found (among the 200 literature citations); however, many more references of importance would have been discovered had a quick manual search been made prior to establishing the keywords for the computer search. The reason for this is that the computer search was too broad including all types of fibers. As might have been suspected, more references to polypropylene were found than desired. The computer search takes place chronologically starting with the most recent publications. It is not surprising that there would be a predominance of references to polypropylene. Important findings from this search are included below.

2. Consultations

Two fiber producers which are big suppliers of yarns for industrial sewing applications have been consulted, namely, E.I. duPont de Nemours and Co., and the Celanese Corporation. One thread manufacturer, Coates and Clark has also been consulted. This company has been manufacturing sewing threads including industrial threads for more than 100 years and is currently involved in supplying new, novel industrial threads and specialty threads. Examples include an industrial thread of polyester described as an air textured continuous filament thread, e.g. a thread having a denier of approximately 1000 and a breaking strength of 10 lbs. Other specialty threads include those made from:

a. polycarbonate
b. poly(tetrafluoroethylene)
c. threads containing stainless steel
d. extended chain polyethylene Allied "Spectra". The fiber in this thread is reported to have a tenacity of 30g/denier, approximately four times as strong as high tenacity polyester and nylon 6,6 fibers!

Mr. Larry Haddock of the Georgia Southern Technical Institute is the head of their textile program which includes a very successful program in apparel manufacturing. Conversations have been held with him concerning the sewing thread requirements for the AstroTurf application. More discussions are needed. These will take place in the near future, probably during the week of July 14.

III. Factors Influencing the Life of a Sewing Thread in the AstroTurf Application.

After reflections on the information found in the literature, that derived from discussions with fiber manufactures thread manufacturers, and thread users (Mr. Haddock) and other reading, I believe that the factors influencing the life of a sewing thread in the AstroTurf application are as follows.

1. The inherent mechanical properties of the fiber used, its tenacity, modulus, toughness, abrasion resistance. Abrasion resistance may very well be more important than tensile properties.

2. The changes in these mechanical properties when exposed to the environment.

Although the effect of light exposure is most important the changes due to degradation by oxides of sulfur and nitrogen, and by ozone cannot be ignored. Also, when the threads are exposed to light there is a rise in temperature above the ambient temperature. For any chemical degradative processes involved, their rates will be increased. AstroTurf is known to reach temperatures as high as 150°F on a hot sunny day. The relative humidity of the environment must be considered, since hydrolysis of the fibers in the thread may occur leading to a loss in mechanical properties.

3. The effect of fiber additives on the mechanical properties.

The fiber additives which influence the mechanical properties of fibers exposed to an out-doors environment include:

1. Additives used in the manufacture of the fiber:
   a. TiO_2 (delustrant)
   b. light stability additives
   c. heat stability additives.

2. Additives used by the fiber user (textile manufacturers)
   a. antioxidants
   b. ultra-violet light screening agents
   c. dyes
   d. other additives to achieve processing properties, e.g. lubricants.

4. Thread Construction
   a. Staple (spun) thread count of yarn and how plied.
   b. Continuous filament thread count of yarn and how plied
   c. Core-spun thread. (continuous filament core and staple sheath)
   d. Air textured threads
   e. denier of filaments comprising the thread.

5. Other
   a. Lubricity of thread
   b. Bonding agent used

IV. Summary of Findings

1. The most intrinsically photo-stable fibers on the market are acrylic fibers.

2. The most intrinsically wear-resistant (abraision resistant) fiber is nylon. There is some controversy as to which nylon, 6,6 or 6 is superior in this respect. Nylon 6,6 most likely has the edge. Acrylic fibers have the poorest abrasion resistance of common fibers used in threads. Note that Monsanto has recently announced a new acrylic fiber for hosiery which has much better abrasion resistance than that of previous fibers.

3. The fiber of choice for threads for sewing industrial fabrics is polyester continuous filament; however the basis for this choice is not clear. The cost of polyester relative to that of other filament yarns may be the controlling factor.

4. Where strength is the primary consideration, the industrial threads are usually made by plying high tenacity continuous filament polyester yarns and, as is the case with Hemingway and Bartlett threads, by cabling the plied yarns with the addition of a bonding agent to produce the finished thread.

5. Bright filaments (extremely low TiO2 content) have much greater photo-stability than semi-dull and dull filaments (up to 2.Ø% TiO2). This is true for nylon 6,6, polyester, and polypropylene filaments but apparently not true for acrylic fibers.

6. Most judgements of the relative photo-stability of fibers are made on the basis of changes in the yarn properties at

rupture, i.e. their tenacity and their percent elongation at rupture. Of equal importance are the changes in abrasion properties (wear) with light exposure.

7. Most synthetic fibers for industrial applications have been stabilized in their manufacture to provide better heat and light stability. These fibers inlude nylon, polyester, and polypropylene. Therefore, any attempt to improve their heat and light stability by the incorporation of more stabilizer in the fiber may be fortuitous. Of course the stabilizers may be incorporated in the bonding agents used for industrial threads leading to improved properties.

8. Color-sealed black nylon and poleyster have much greater photostability than the uncolored fiber. Again, the judgement of photostability is based on changes in the fiber strength.

9. For threads made from multifilament polyester yarns (high tenacity), there is some evidence that the filament denier is an importance consideration. For example, Hemingway states that their threads V-277 and V554 are based on:

Fortrel T-77Ø 22Ø/72 or equivalent

Dacron T-68 22Ø/5Ø

and for thread V-693

Dacron T-68 111Ø/?

or

equivalent material.

Note that the denier per filament of the Fortrel yarn is 3.Ø whereas for the duPont yarn the denier per filament is 4.4. Celanese who market Fortrel is now moving to a 22Ø/48 yarn for industrial sewing threads (4.4 denier per filament). In Europe, the polyester yarn of choice has this higher denier per filament, 4.4. The impetus for increasing the denier per filament appears to be the greater abrasion resistance of nylon, 84Ø/14Ø (6 denier per filament).

1Ø. Some dyes on nylon promote photodegradation and some have a stabilizing action.

V. Candidate Sewing Threads-Preliminary Suggestions

1. A plied and cabled black color-sealed continuous filament thread of polyester or nylon. Nylon would probably be preferred because of its superior abrasion resistance.

2. An air-textured continuous filament thread using the black color-sealed fiber, polyester or nylon.

3. A thread made from continuous filament nylon 6,6 filaments pigmented and stabilized in the same way that AstroTurf ribbons are pigmented and stabilized.

4. A core spun thread in which the core is high tenacity polyester continuous filament or high tenacity nylon 6,6 continuous filament and the sheath is acrylic fibers. The new more abrasion resistant acrylic made by Monsanto may be applicable. Note that continuous filament acrylic yarns are available for blending with other filaments via an air texturing process. For such threads including acrylic fibers abrasion resistance will be provided by polyester or nylon and the acrylic fibers will provide an ultra-violet screening function.

5. Threads in which the filament denier is greater than that in currently used threads. Improved light stability should results from an increase in the denier per filament used to make the thread. The degradation process occurs at the fiber surface and as the filament denier is increased there is a decrease in the surface area per unit volume of the fiber. Hemingway and Bartlett state that they make their threads V-277 and V-554 from Fortrel T-77Ø (3 denier per filament) or 'its equivalent' Dacron T-68 (4.4 denier per filament). Note that these yarns are not equivalent!

The suggestions described above for an improved threaed are an attempt to provide my thinking at this early stage in the research program. Other possibilities for solving the problem will undoubtedly surface.